EXPLANATION OF PLATE VIII.

Fig. 1. *Dictyna borealis*, sp. n., ♀: *a*, profile of cephalothorax; *b*, fore part of caput and falces; *c*, *maxillæ*, *labium*, and *sternum*; *d*, spinners; *e*, natural size of spider.

Fig. 2. *Erigone Whymperi*, sp. n., ♂: *a*, profile without legs; *b*, fore part of caput and falces; *c*, *d*, *e*, palpus of ♂ in different positions; *f*, genital aperture of ♀; *g*, natural size of spider.

Fig. 3. *Erigone arctica*, White: *a*, left palpus of ♂, from the outer side; *b*, natural length of palpus.

Fig. 4. *Erigone psychrophila*, Thor.: right palpus of ♂, from the inner side above.

Fig. 5. *Erigone provocans*, sp. n.: *a*, spider, enlarged; *b*, profile without legs; *c*, left palpus, from beneath on the outer side; *d*, natural length of spider.

Fig. 6. *Erigone vexatrix*, sp. n., ♀: *a*, spider, enlarged; *b*, profile without legs; *c*, fore part of caput and falces; *d*, genital aperture, in perspective; *e*, ditto, in front; *f*, natural length of spider.

Fig. 7. *Tarentula exasperans*, sp. n., ♀: *a*, spider, enlarged; *b*, palpus and palpal organs; *c*, natural length of spider.

XXXVI.—*On the Changes produced in the Siliceous Skeletons of certain Sponges by the Action of Caustic Potash.* By W. J. Sollas, M.A., F.G.S., formerly Scholar of St. John's College, Cambridge.

[Plate IX.]

Amongst the various problems which have arisen in the difficult study of the sponges, that as to the exact nature of the skeletal network of such genera as *Farrea*, *Dactylocalyx*, and *Aphrocallistes* has not been one of the most easily solved.

Bowerbank, who was the first to express an opinion on the subject, regarded the vitreo-hexactinellid network as the exact representative amongst the Silicea of the horny network of the kerataceous sponges. In the latter he had previously distinguished two marked types—one in which the horny fibres are solid throughout (*Spongia officinalis*), and another in which the axis of the fibre is occupied by a hollow canal (*Verongia*). The same difference he now stated to exist amongst the siliceous-netted sponges, and upon it separated the genera *Dactylocalyx*, *Iphiteon*, and *Myliusia*, the fibres of which he regarded as solid, from certain other genera (*Kaliapsis*, *Farrea*, and *Purisiphonia*), which he considered to possess canaliculated or "fistulose" fibre. The interpretation next advanced appears to have originated with the late Dr. Gray, and was adopted with wider application by Professor Sir Wyville Thomson *, who,

* 'Annals and Magazine of Natural History,' February 1868, p. 114.

in 1868, stated it as his opinion that the network of the siliceous-netted sponges was produced by an anastomosis, fusion, or coalescence of sexradiate spicules with one another.

This opinion was at once endorsed and supported with various new observations by Oscar Schmidt. The objection urged by Dr. Bowerbank to Gray and Thomson's view was, that true spicules never evince any tendency to fuse together: thus in 1869 he states that he has "never yet seen a case of the anastomosis of spicula. The normal condition of these organs is never to anastomose, however closely they may be packed together."

So the question stood till 1873, when it was reserved for Dr. Carter to bring these opposing views into harmony, and so to explain in the most beautiful manner the real structure of the netted Hexactinellidæ. In a paper on the Hexactinellidæ and Lithistidæ he proves, from observations of very young specimens, that at first the netted sponge *Aphrocallistes* possesses no other skeletal elements but separate free sexradiate spicules, and that the formation of a network is a subsequent process brought about as growth advances by the envelopment of the free spicules in a coating of siliceous material, which, running over each and from one to another of them, at length involves them all in continuous siliceous fibre. The network of *Aphrocallistes* and of other netted sexradiate sponges is accordingly a composite structure, not simply fibrous in the sense that the horny skeleton of a washing-sponge is so, nor, on the other hand, simply spiculose, as if it consisted of ankylosed spicules merely, but spiculo-fibrous like the network of the Chalinids; only in this case the simple acerate spicules of the Chalinidæ are represented by sexradiate ones, and the horny substance of their fibre is replaced by siliceous material.

This interpretation was supported by the fact that the original spicules on which the fibre of the network is built become absorbed some time after the death of the sponge, and so reappear in the interior of the fibre as hollow sexradiate casts, which in time, however, may, with continued internal absorption of the fibre, so increase in size as to become continuous axial canals, in which state they seem to have been observed by Dr. Bowerbank, and so came to be regarded by him as a proof of the existence of normally fistulose fibre amongst the siliceous sponges. It is important to add that, besides casts of ordinary sexradiates, Carter also observed those of other forms, notably of the curious besom-shaped spicule which is so characteristic of *Aphrocallistes*.

As regards the cause of the absorption by which the imbedded spicules are again revealed, Carter says no more than that it is a chemical question, and that in consequence he leaves it to the investigations of the chemist. It was partly with the hope that I might be able to throw a little light on this subject that the following investigation was undertaken.

The spicular silica of sponges has for a long time been known to be somewhat soluble in caustic potash, so that spongologists seldom, if ever, employ this reagent to remove from sponge-skeletons the organic matter associated with them—a use for which otherwise it would be well fitted. Considering this, it appeared to me that in caustic potash we possess a valuable means for the analytical treatment of sponge-spicules, so as to be able to dissect them into their structural elements, and to reproduce in them those characters which they exhibit in the deciduous state both recent and fossil.

Specimens of various vitreo-hexactinellids were accordingly procured, and subjected to a microscopical examination to make sure that they were in the fresh state, or, in other words, had not begun to be excavated by internal spicular casts. This ascertained, they were next exposed to the action of strong boiling caustic potash for varying intervals of time. The changes thus produced will now be described.

Dactylocalyx subglobosus.

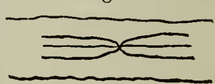
The solid fibres of this sponge soon exhibit delicate canals, which start from the broken ends of the fibres, and radiate, as a rule, from the nodes of the skeletal network, each stellate group of canals forming a single sexradiate system with its centre generally situated in or about the centre of a node. The canals are at first very small and may be regarded, I think, as representing simply the enlarged axial canals of the imbedded sexradiate spicules. This stage of solution we may call stage 1. As the boiling continues, the canals progressively enlarge and come to occupy a very considerable portion of the interior of the fibre, till at length they appear to coincide with the walls of the imbedded spicule on which the fibre is constructed (stage 2). That the canals do at length really represent the original spicule is shown by the reappearance of the besom-shaped spicule in *Aphrocallistes*. Finally the canals extend so far and widely as to touch and open into each other and thus channel the fibre continuously or render it truly "fistulose" (stage 3). This is the condition in which the skeletons of the vitreo-hexactinellids are usually found when fossil, though it is by no means rare to find the preceding stage well represented also. It is moreover the state in which the only known specimens of *Farrea occa* and *F. facunda* exist, and which occurs sometimes in *Aphrocallistes Bocagei* and, according to Bowerbank, in *Purisiphonia Clarkei*, while the second stage is exhibited in skeletons of *Aphrocallistes Bocagei*, *Dactylocalyx pumiceus*, and *D. crispus* (O. S.), which, however, like the genera *Iphiteon* (Bk.) and *Myliusia*, are usually found in the fresh state and consequently with solid fibres.

As regards the characters of the canals themselves, they are in my specimens exclusively sexradiates; but they differ in a marked manner from the loose separate sexradiates which do not become involved in the siliceous fibre; for while the latter are always rectangularly triaxial, the involved spicules are neither rectangular nor triaxial at all, except in the rarest cases. Each arm of an imbedded spicule may make any angle with its fellows; there is no constancy in this respect, nor any approach to it. This will be seen by reference to fig. 1, Pl. IX., and is even more strikingly exhibited in some specimens which are not here figured.

It would seem as though the free sexradiate spicules of the sponge lost their usual rigid regularity and became instead perfectly pliable to all the changes in direction of the siliceous fibre as soon as they became involved in it, the fibre governing the direction of their rays to the complete subordination of their intrinsic tendency of growth.

On the other hand the centre of each sexradiate spicule appears in most cases, but not in all, to determine the position of a node of the fibrous skeleton, each node corresponding in position to the centre of an imbedded spicule. The exceptions are where three arms of a sexradiate are bent in one direction approximately parallel to each other, and the other three in the opposite direction, so that the whole spicule comes to be imbedded in one and the same straight fibre (fig. 1).

Fig. 1.



Here, then, a sexradiate exists without a corresponding skeletal node; and more frequently still it happens that a node may exist independently of the presence of a sexradiate centre, *ex. gr.* where three or more arms of adjacent sexradiates join together.

It need not be added that though the nodes of the skeleton are generally determined by the presence of sexradiate spicules, they are not on that account necessarily sexradiate themselves, since by the coincidence in direction of two or more arms of one spicule, or by the addition of rays from an adjacent spicule, a node may become four-, five-, six-, seven-, or even eight-rotulate.

The siliceous cement which, with the included spicules, forms the skeletal fibre does not scale off under the action of potash in concentric layers, as happens in the case of true spicules, but dissolves away amorphously both in the interior and on the exterior of the fibre, without in the latter case producing those hemispherical pit-like markings which cover the exterior of many deciduous recent and fossil spicules, and which in some cases have been shown by Mr. Carter to result from the depredations of some algoid parasite.

Fine longitudinal striations, however, are generally observable along the fibre, and may perhaps indicate a lamellar structure; in one or two instances I have seen indications of more rapid solution at a point (p) midway between the spicular canal and the periphery of the fibre, thus (fig. 2), as though along the line where the siliceous cement first covered over the contained spicule.

Fig. 2.

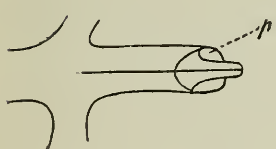
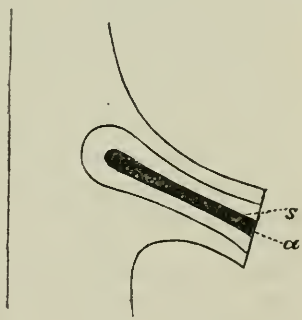


Fig. 3.



The appearance shown in fig. 3 seems to result from a change in the refractive index of the spicular component of the fibre; for the included spicule (s) is quite distinctly defined from the surrounding fibre and is yet composed of solid silica, which opposes the expansion of a well-defined thread of air (a) contained in its relatively narrow axial canal.

Long before the spicular canals in the interior of the fibre have become fully developed by the action of the potash, the minute "rosettes" of the sarcode have completely disappeared in solution, so that before stage 2 is passed a careful search with high powers fails to reveal even the slightest trace of them.

The free sexradiates follow shortly after; but the spines of the fibre remain for some time longer, and do not disappear till the last stage of solution has been reached or has even become far advanced.

Aphrocallistes Bocagei, Dactylocalyx pumiceus, Farrea densa, Myliusia callocyathes.

The sponges next submitted to experiment were the four just named, of which *A. Bocagei* and *D. pumiceus* have been found both fresh and in the deciduous state, and consequently with fibres both channelled and solid, while the two latter, like *D. subglobosa*, are known only in the fresh condition with solid glassy fibres. In all, however, results were obtained on boiling with caustic potash precisely similar to those already described in the case of *D. subglobosa*. The canals of the imbedded spicules were enlarged and made visible; the enlargement continued till the entire spicule was dissolved out; and finally the spicular casts ran together and the fibres became hollow tubes: the rosettes and loose sexradiates soon passed into solution; while the spines of the fibre persisted for a considerable time, traces of them remaining when the canals had attained their fullest development.

The attached sexradiates of many vitreo-hexactinellids, when the siliceous cement has only just commenced to spread over them, are frequently capitate at the extremities of their rays, as though the enveloping silica had been fluid and accumulated in greater quantity at the points of the rays than along their sides, as, in fact, the sarcode from which the silica is deposited may have done. Curiously enough, the casts of the spicular rays excavated in the siliceous fibre frequently terminate in the same capitate manner; and it is possible that when they do so the retrogressive metamorphosis of the fibre has brought it back to exhibit in an inverse form the same early stage as that to which we have just alluded.

Euplectella aspergillum.

The axial canals of both its free and combined spicules were first developed; and a concentric laminar structure was next exposed both in them and in the cementing material, which here only binds the spicules into bundles without absolutely enveloping them. As in time the cementing silica becomes wholly dissolved away in places, the spicules it unites together are to a great extent set free; and the composition of the longitudinal and transverse fibres formed by them is then made manifest.

Hyalonema Sieboldii.

Mr. Higgin, of Liverpool, gave me a beautiful specimen of one of the anchoring spicules of this sponge; it was perfect from one end to the other, including the barbed head and denticulated scalar lamina. The great length and size of this spicule had previously led me to imagine that, although apparently nothing but a simple spicule, it might yet upon investigation be found to consist of several spicules imbedded in a siliceous fibre.

A careful examination was therefore made to determine this point; with sharp scissors the spicule was divided into convenient lengths and then boiled in potash. The axial canal soon became clearly visible and could be continuously traced from one end of the spicule to the other; it was obviously quite simple, and radiated once only, viz. in the barbed head, where it forms a sexradiate cross: no other canal in addition to this could be detected in the spicule, which thus, contrary to my expectation, was proved to be not spicular fibre but a simple spicule after all. With the development of the axial canal several faint lines or cracks, circumferential in direction, appeared on the exterior of the spicule, and were immediately traversed by others running longitudinally; the outermost layer then peeled off in strips between the circumferential cracks; and as the process continued, other laminæ were exposed and similarly scaled away. The ends of the various lengths of the divided spicule soon lost their cylindrical form and became conical, the alkali dissolving backwards the successive concentric laminæ of which the spicule was composed, the outermost first and consequently most extensively, and the rest in successive order, till at length the original strand on which all the rest had been formed was exposed as a single thread with an axial canal which, as happens in all similar cases, was expanded towards its termination, funnel-shaped (as in fig. 5, Pl. IX.).

Nothing can exceed the elegance with which caustic potash exposes the concentrically lamellar structure of this spicule: each individual lamella is so perfectly separated from its fellows that one can count the number of which the spicule is composed at various points of its length; thus in the figure (Pl. IX. fig. 5) ten laminæ are to be seen.

The sponges next examined belong to other orders than that of the Hexactinellidæ.

Geodia arabica.

In spicules with sharp points, like the anchoring and acerate spicules of this sponge, the axial canal extends to within a very short distance of the pointed extremity; so that as the spicule yields to the action of the potash and the fine point is quickly dissolved away, the axial canal is soon exposed and the potash finds easy access to the interior of the spicule. The axial canal then rapidly begins to enlarge, and soon expands into a funnel-shaped termination towards its extremities, or where the potash first enters. The sides of this funnel-shaped expansion, when viewed with a high power, do not appear in optical section as simple straight lines, but are very finely "stepped" all the way down, each step representing very obviously the exposed edge of one of the concentric lamellæ of which the spicule is made up. The concentrically lamellar structure of these and all other true spicules is, indeed, beautifully revealed by this method of solution, more perfectly and in a far clearer way than by the process of charring the spicule with heat, as in the flame of a spirit-lamp.

As solution proceeds, the points of the spicules become entirely removed, and a fusiform acerate spicule becomes almost cylindrical from the loss of its conical ends: but the different lamellæ never dissolve at the same rate; some always resist longer than others; so that at every stage of solution the spicule presents a lamellar appearance. The outermost lamella frequently endures the longest, forming a hollow sheath of infinite tenuity, which frequently splits longitudinally so as to form two or more long narrow strips or ribbons; and these, in some instances, curl backwards and outwards in a very singular way. A fossil spicule in this last state would not be readily recognized for what it actually was, and has been, indeed, on more than one occasion a source of considerable difficulty to myself in studying the spicules of the Cambridge coprolites.

The anchoring spicules undergo just the same changes as the acerates; but their short conical arms dissolve much faster interiorly than the longer shafts, because the edges of a greater number of concentric lamellæ are exposed over a shorter length than in the shaft, and so present in the same space a larger number of *points d'appui*, so to speak, for the action of the caustic potash.

The spicules which undergo the most remarkable alteration, however, are the "globo-stellates," which Bowerbank mistook for ovaria. The interior of these, at first optically homogeneous, soon exhibits a radiate structure starting from the centre (Pl. IX. fig. 6), and with its separate rays terminating at unequal distances short of the exterior; as solution continues a small cavity is developed in the centre, the radiate structure is better displayed and extends much further towards the circumference (Pl. IX. figs. 9, 8), the small cavity continuously enlarges till at length it occupies the whole interior of the globo-stellate *, leaving only a thin outer film, perforated in places and much resembling a broken egg-shell. If Bowerbank had under his observation globo-stellates which had suffered this change under the influence of atmospheric solvents, he might well be forgiven for falling into the error he did respecting them.

By careful observation, it will in most cases be found that the potash obtains entrance to the interior of these spicules by way of the "hilum" which characterizes all of them. One can sometimes look down and through the hilum into the cavity excavated within; and frequently one may observe by a lateral view a canal from the hilum in direct continuity with the inner cavity (Pl. IX. figs. 8, 9, 11). It is very noteworthy that while solution has proceeded to such an extreme extent in the interior of the globo-stellates, the exterior is, on the other hand, often scarcely affected. Originally the outer surface is ornamented by spines, which divide at their summits into four or five smaller spines, and which are united together by lateral ridges into a compact network; the chief result of the action of the potash on the exterior is apparently to dissolve away these connecting ridges, and so to leave the spines in isolation and much better exposed for an examination into their minute characters (Pl. IX. figs. 12, 13). The reason for the difference in the rates of solution within and without these structures appears to lie in the fact that when once the potash has reached the centre of a globo-stellate, it is able to attack the ends of the rays of which it is composed and to penetrate between their sides, while it finds it more difficult, apparently impossible, to insinuate itself between them when acting on the outside; thus the surface over which the potash in the interior acts is many times larger than that exposed to the influence of that without, and in consequence the internal solution is necessarily much more rapid. In some few cases I have observed globo-stellates with all their spines removed from the exterior, so as to present a smooth surface: in these the way to the interior appears to

* It often happens that the central cavity of such globo-stellates contains a white opaque kernel-like spherule (Pl. IX. fig. 7, *s*), the nature of which was at first very puzzling to me; for though I suspected it to be an air-bubble, I could get no metallic lustre from its surface with reflected light. By pressing on the covering-glass immediately over one of these spherules, however, with a pointed piece of wood, it was found possible to crush the globo-stellate containing it; for the globo-stellates when partly dissolved are very brittle and break easily. There then remained only transparent fragments of the broken shell and an indubitable glistening air-bubble lying in their midst. By carefully performing the operation one could, indeed, see the air-bubble issue from the globo-stellate at the moment of fracture.

have been sealed up; at all events no internal solution had taken place.

The small stellates and other delicate spicules of this *Geodia* dissolve and disappear at a very early stage, so that none of them are to be seen in my slides amongst the partially dissolved larger spicules.

Pachymatisma Johnstonia.

In the cylindrical spicule of this sponge the ends of the axial canal are much further removed from the extremities, and consequently better protected than they are in the case of the acerates we noticed in *Geodia*; but since neither end of the canal is better protected than the other, we find as a rule that both are exposed at about the same time, and so in the majority of these spicules the action of potash is to remove both ends and develop the axial canal from each extremity, in just the same way as in the case of the acerates of *Geodia* (Pl. IX. figs. 16, 17).

I may here take the opportunity to record a very abnormal occurrence in connexion with these spicules, that, viz., of two of them existing in a state of complete ankylosis. The axial canals in this ankylosed structure have been made very visible by the caustic potash, and can be seen crossing each other at one point without intercommunication, so that each spicule possesses its own distinct canal quite separate from that of its fellow, and neither can be regarded as a mere process of the other. The fact of their ankylosis is easily determined by mere inspection (Pl. IX. fig. 18). Bowerbank's dictum, that spicules never ankylose together, not even by morbid growth, is thus seen not to be of universal application*.

The globo-stellates behave very much as those of *Geodia*; but in the examples I have had before me one or two additional phenomena have been observed. In the first place the hemispherical pits which are so common on fossil spicules are here produced artificially by the action of the caustic potash in great abundance, marking the spicules all over with regular excavations of just the same size and appearance as those which are seen in the fossil examples (Pl. IX. figs. 10, 11). The same hemispherical pits also appear on the acerate and large anchoring spicules of *Geodia arabica* after boiling with potash; in these cases the successive laminæ of the spicule are exposed in circles concentric with the circumference of the excavation (Pl. IX. fig. 15).

Next, in one or two instances a thin structureless exterior

* See also O. Schmidt, Spong. d. Küste v. Algier, p. 16, Taf. iii. fig. 2.

film separated itself from the interior mass of a globo-stellate, which everywhere remained free within it. The film was not smooth, but wrinkled all over so as to fit exactly on to the spines it once covered, dipping into the depressions between them and rising over their summits (Pl. IX. fig. 14, *f*). Is this film the silicified wall of the cell in which the spicule has been developed? or is it the last coating of silica which the spicule had received? If the latter be the true interpretation, the phenomenon is but a repetition of what we have already observed in the case of elongated spicules, where the outermost lamella frequently remains after solution as a mere sheath about the rest of the spicule within it.

In this sponge the potash is more frequently able to attack the component rays of the globo-stellates from the exterior than in *Geodia arabica*, and hence the solution in a radial direction sometimes proceeds both from within outwards and *vice versâ* simultaneously.

The stellates of *Pachymatisma* appear to have greater power of resistance than those of *Geodia arabica*, since a slide showing many of the globo-stellates of the former reduced to the condition of thin shells also contains instances of its stellates which have survived solution, and, indeed, appear but little the worse for it. With this fact may be coupled another, viz. that stellates similar to those of *Pachymatisma* have been seen by me in the fossil state amongst a number of other spicules which I am now describing from the Chalk of Trimmingham, Norfolk.

Trachya, sp.

The staple spicule here is a large acuate, the rounded end of which affords great protection to the corresponding termination of the axial canal within it, while at the pointed end only a thin layer of silica intervenes between the axial canal and the surrounding potash. It hence happens that at the rounded end the canal remains closed and the concentric lamellæ of the spicule are there with difficulty dissolved away; while at the pointed extremity the canal is entered by the potash at once, the edges of the concentric lamina are exposed and rapidly attacked, and the spicule is eaten back from the point towards the butt, so that it is soon nearly all destroyed, the part that remains often being only the butt-end, which even then preserves the blind termination of the canal unbreached from behind (Pl. IX. fig. 19, *b*).

At the round end the potash removes the concentric lamellæ from without inwards, so that the innermost project furthest (Pl. IX. fig. 19, *b*); at the pointed end the potash acts from within outwards and the outermost lamellæ usually endure longest (fig. 19, *a*).

The smaller spicules of this *Trachya* have been entirely dissolved by the solution, which has merely analyzed the larger ones.

Halichondria incrustans and *H. panicea*.

The flesh-spicules (anchorates and tricurvates) of the former species soon passed into solution; and in the skeleton-spicules of both, the axial canals very quickly appeared and rapidly enlarged. A concentric lamellar structure was exposed as in the cases we have previously described; but in these small spicules the number of component laminæ appears to be very small, not above two or three at the most. One has to be careful in attending to the solution of these spicules, not to let them boil too long; otherwise they may all dissolve away: a boiling sufficient to develop the spicules of the *Trachya* of the preceding paragraph completely dissolved all or nearly all the spicules of a specimen of *H. incrustans*. From this one might conclude that a search for fossil spicules of so small a size as these would not, unless under very favourable circumstances, be likely to be attended with success.

This concludes the account of the observations on the action of caustic potash which I have thought it worth while to record; and it only remains to add a few words by way of application and explanation. And first as to the curious fact that solution appears to proceed much more rapidly in the interior than on the outside of spicules or spicular fibre, so that very frequently we find the exterior of a spicule persisting as a thin shell of apparently the same diameter as it had originally, while interiorly every thing has been dissolved away. It may be said that the difficulty here is more apparent than real, since the internal solution takes place under circumstances very favourable for observation, while that of the exterior is less easily made manifest. When it reveals itself in the edges of eroded laminæ (Pl. IX. fig. 19, *a* & *b*) it is obvious enough; but in most instances its effects cannot so readily be estimated. There is no doubt some truth in this; but in many cases the difference in the rate of the internal and external solution is too great to be accounted for in such a manner. Capillarity will not help us much; for it could only lead to the introduction of the potash into the fine axial canal and between the successive concentric lamellæ of the spicule, and assist solution so far only as it might do so by bringing the solvent agent into every accessible crevice of the dissolving substance. In many cases the explanation is to be sought in the structure of the spicule itself, the edges of its component layers or component rays being more readily reached from within than from without, as, for instance, along the axial canal of a linear spicule and around the central cavity of a globo-stellate.

In the case, however, of the spicular fibre of *Dactylocalyx* and its congeners, the internal solution is still in excess, though no exfoliation of lamellæ appears in them to take place. Possibly the interior, and therefore older, silica of the fibre has suffered some change with age, by which its solubility has been increased; but in the absence of any thing better than mere speculation it will be as well to wait for an explanation till one is met with in the natural course of future observations.

We may next observe that the solution we have accomplished in the laboratory also occurs on the large scale in nature, *ex. gr.* at the bottom of the sea, where deciduous spicules soon become partially dissolved, with the production in every detail of the characters we have just described, and are afterwards silted up to exhibit these characters in a fossil state. But while in caustic potash we have a substance which will dissolve some kinds of silica with the production of a definite chemical compound, viz. potassic silicate, we do not know, on the other hand, of the presence of any reagent in sea-water which is capable of effecting the same result; the only widely diffused solvent there, with which we are acquainted, excepting the water itself, is carbonic acid; and no one has yet shown that this acid is capable of dissolving any kind of silica, or that water alone, given time enough, is incompetent to the task. That one or other of these substances does in certain cases dissolve that kind of silica which is soluble in caustic potash is shown, however, by the changes produced by rain-water on the freshly fractured surfaces of black flints; a comparatively short exposure of these to atmospheric agencies soon causes them to lose their black translucent appearance, and to become opaque and white, owing, as a microscopic examination proves, to the removal of some of the silica from the exposed face, so as to render it at first irregularly pitted and subsequently porous. The only agent to which this removal can be attributed is rain-water; but since this consists both of pure water and carbonic acid, we are still unable to say whether the presence of carbonic acid is a necessary condition to this solution or not. As to the efficacy of one or other of these substances, however, this observation leaves us in no doubt; and since both carbonic acid and water occur together at the bottom of the sea, we have there just the conditions under which the solution of silica must necessarily take place; and when, in the course of some years, this solution has been accomplished, it will have produced just those changes in deciduous spicules which we have succeeded in bringing about in a few minutes*.

Summary.

1. By boiling with caustic potash, spicular silica passes into solution.

2. In dissolving sponge-spicules, solution takes place both on the outside of the spicule and internally about the sides of its axial canal.

3. In vitreo-hexactinellid fibre, the internal solution at first reproduces as hollow casts the forms of the spicules upon

* If for the sake of hypothesis we assume, according to all analogy, that carbonic acid is the essential ingredient in atmospheric or sea-water for the solution of dissolvable silica, and that some loose compound of silica and carbonic acid is formed by its action, we may then be able to formulate in an intelligible manner the replacement of spicular silica by carbonate of lime, a change of which a large number of examples are now known to spongologists. Given, for instance, a solution of calcic dihydric carbonate (bicarbonate of lime) containing but a very small excess of free carbonic acid, such as might naturally be expected to exist in a bed composed of fragments of calcic carbonate (*e. g.* in a bed of chalk), and its action on spicular silica might then be represented as follows:—

$$\text{(i) } \underset{\text{(Sponge-spicules.)}}{\text{Dissolvable silica}} + \underset{\text{Calcic dihydric carbonate.}}{(CO)_2(OH)_2(CaO_2)}$$

$$= \underset{\text{(Dissolved silica.)}}{\text{Compound of silica and carbonic acid}} + \underset{\text{Calcic carbonate.}}{CO(CaO_2)}$$

Thus calcite would become pseudomorphic after siliceous spicules, and silica would pass into solution. But we also know from observation that the reverse solution frequently takes place; this we may represent in the following equation:—

$$\text{(ii) } \underset{\text{Calcic carbonate, } ex.\ gr. \text{ coral.}}{CO(CaO_2)} + \underset{\text{(Dissolved silica.)}}{\text{Compound of silica and carbonic acid}}$$

$$= \underset{\text{Calcic dihydric carbonate.}}{(CO)_2(OH)_2(CaO_2)} + \text{Silica deposited.}$$

Hence these reactions belong to that numerous class known to chemists as reversible; and it follows that the dissolved silica set free by the first reaction (i) might be again deposited on coming into contact with the carbonate of lime in excess in the surrounding bed, according to the reaction given in equation (ii); and thus, in one and the same sponge-skeleton, the solution of spicular silica, its replacement by carbonate of lime, and the redeposition of the dissolved silica might be proceeding simultaneously. In some such manner may the mineral arrangements which I have described in *Stauronema* and *Pharetrospongia* have been brought about.

which the fibre has been formed, and afterwards enlarges and unites these together so as to form a continuous canal in the axis of the fibre.

4. The "rosettes" and other flesh-spicules of the Hexactinellids pass into solution before the hollow sexradiate casts have been definitely produced. This explains the fact that these spicules have never yet been observed in the fossil state.

5. The spines and tubercles of vitreo-hexactinellid fibre persist up to a very late stage of solution, and considerably outlast the rosettes and flesh-spicules.

6. Except in the case of *Euplectella*, the vitreo-hexactinellid fibre does not exhibit a tendency to scale off into concentric layers when undergoing solution.

7. In ordinary spicules the caustic potash insinuates itself between the faces of the component lamellæ, which thus dissolve not only at their edges, but over their whole surface, and in consequence become separated from each other and so display the true structure of the spicule.

8. The globe-stellate spicules dissolve chiefly from within outwards: a central cavity is formed with hollow rays proceeding from it; this cavity continuously enlarges towards the exterior till the siliceous substance surrounding it becomes reduced to a mere film.

The unbuilding of these spicules thus proceeds exactly in the same way as their building-up; the growing hollow cavity with its rays is an exact negative image of the solid sphere with its fine projecting spines that passes at length into the adult globo-stellate form.

9. The solution which suffices to analyze the various layers of a large spicule from each other destroys altogether small spicules, such as those of *Halichondria panicea*.

10. The external solution of the spicules may take place with comparatively greater rapidity at some points than others on the surface, which thus becomes excavated by a number of hemispherical pittings.

11. Dead spicules are soluble also in water containing carbonic acid; and thus arises a correspondence in the characters of spicules artificially treated with caustic potash and those which are dredged up from the sea-floor or obtained in a fossil state.

EXPLANATION OF PLATE IX.

Alterations produced in spicular structures by boiling in caustic potash solution.

Fig. 1. *Dactylocalyx subglobosus*. Skeletal network, exhibiting casts of sexradiate spicules (× 104).

Fig. 2. *Aphrocallistes Bocagei.* Two nodes of the network, with two sexradiate casts, each with one ray prolonged to form the interior of one of the long spines of the interior of the netted tube (×140).
Fig. 3. Capitate termination of a spicular cast in the fibre of *D. subglobosus* (×435).
Fig. 4. *Farrea densa.* A node of the network, exhibiting casts of three imbedded spicules (×104).
Fig. 5. *Hyalonema Sieboldii.* Cut end of a length of the anchoring spicule, with the lamellar structure revealed by solution (×104).
Figs. 6 to 9. *Geodia arabica.* Globo-stellates in various stages of solution: *h*, hilum; *r*, radiate structure; *c*, central cavity; *s*, contained air-bubble (×140).
Figs. 10 & 11. *Pachymatisma Johnstonia.* Globo-stellates: *p*, hemispherical excavations (×140).
Figs. 12 & 13. *Geodia arabica.* Spines of a globo-stellate separated by solution: fig. 12, seen in elevation; fig. 13, in plan (×435).
Fig. 14. *P. Johnstonia.* Globo-stellate: *f*, thin structureless external film of silica, separated from the rest of the spicule within it (×140).
Fig. 15. Hemispherical excavations on the exterior of an acerate spicule of *Geodia arabica*: *a*, one showing the circular outcrop of the concentric lamellæ round its walls (×140).
Figs. 16 & 17. Ends of cylindrical spicules of *Pachymatisma Johnstonia* (×435).
Fig. 18. Abnormal structure, showing two spicules of *P. Johnstonia* ankylosed together (×140).
Fig. 19. *Trachya*, sp. Acuate spicule: *a*, originally pointed end; *b*, rounded end (×435).

XXXVII.—*Notes on Stony Corals in the Collection of the British Museum.* By Dr. F. Brüggemann.

III. A Revision of the Recent Solitary Mussaceæ.

Of the above-named group, which is equivalent to the *Lithophylliacées simples* of Milne-Edwards and Haime, there appear to exist at least four genera comprising living species. They may be tabulated in the following manner:—

A. Without a distinct epitheca .... 1. Scolymia.
B. With an epitheca.
  a. Edges of the larger septa roughly lacero-dentate, the outermost teeth the strongest .... 2. Cynarina.
  b. Edges of the septa equally dentate.
    1. Columella large, spongious .... 3. Antillia.
    2. Columella small, trabecular........ 4. Homophyllia.

Taking other characters into view, another arrangement can be made:—